ASPECTS OF THE LIMNOLOGY OF FIVE SMALL RESERVOIRS IN NEW SOUTH WALES

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Synopsis

Three small reservoirs in the Maitland-Cessnock area and two in the adjacent Wyong area of New South Wales were studied for various periods up to three years. One is deep (16 m), warm monomictic and oligotrophic, while the others are shallow (< 8 m) and, save one, eutrophic. The ones protected from wind stratify during summer, but the exposed ones only do so intermittently. The incidence of floods, rather than season, determines the pattern of transparency and pH changes.

The limnetic zooplankton cycles are somewhat irregular, due mainly to the influence of floods and droughts. Blooms usually occur in spring and sometimes in autumn also. Most of the 17 cladocerans are aestival with spring and/or summer appearances while all seven copepods are perennial. Almost all species are di- or polyacmic and multivoltine. An average of 9·0 entomostracan species occur in the limnetic region of each reservoir with 4·7 being present at any one time and only 2·2 causing blooms.

Introduction

The general features of limnological cycles in overseas reservoirs are well known (e.g., Hrbacek, 1966; Lowe-McConnell, 1966; Pennak, 1946, 1949), but information is lacking on Australian examples. Some data are provided by Jolly (1966), Timms and Midgley (1969) and Weatherley (1958). These reservoirs may have unusual features because of the high degree of endemicity of the fauna (Williams, 1965) and extreme climatic conditions (C.S.I.R.O. Aust. 1960).

This paper attempts to add to the understanding of the limnology of Australian reservoirs, particularly of the smaller ones which are becoming a common feature of the Australian rural scene.

The Reservoirs

Three of these are situated in the Lower Hunter Valley (near Cessnock) and two on the coastal plain near Wyong (Table 1, see also Fig. 1, Timms, 1970). Except for Mardi Dam which was constructed in 1962, all are at least 40 years old. Maitland Power Station Dam is used as a cooling pond for a small thermal power station; Mardi Dam is a public water storage reservoir; the remainder are unused.

All the reservoirs are relatively small and shallow (Table 1). Further data is given in Timms (1970). Their aspects differ considerably: reservoirs 1 and 2 lie in open grazing land and are exposed to wind; reservoirs 3 and 5 occur in wooded valleys and are protected; reservoir 4 is partly exposed. The degree of exposure to winds has considerable bearing on temperature regimes (see later).

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TABLE 1

The reservoirs—location, surface area, maximum depth an sampling period

Reservoir			Surface area (ha)	Maximum depth* (m)	Sampling period	Time of day when sampled (hours)
Name	Location	Number				
Richmond Main Colliery Dam ..	15 km S. Maitland	1	29	5·7 (3·0)	Mar. 1966–Feb. 1969	08·00±1·00
Maitland Power Station Dam ..	2 km N.W. Maitland	2	18	8·0 (7·0)	Mar. 1966–Feb. 1969	09·00±1·00
Abernethy Colliery Dam ..	7 km S.E. Cessnock	3	6†	6·0 (4·5)	Mar. 1966–July 1969	10·30±1·00
Mardi Dam	3 km S.W. Wyong	4	66	16·0 (15·0)	Mar. 1967–Feb. 1969	12·00±1·00
Morisset Dam	19 km E.N.E. Wyong	5	7†	4·0 (3·5)	Mar. 1967–July 1968	13·00±1·00

* Figures in brackets indicate the lowest maximum depth during study.
† Estimated.

The geological and climatological background is similar for each. The catchment areas are composed of sandstones, conglomerates or shales (Nasher, 1964, 1967) which are covered by podzolic and skeletal soils (van de Graaff, 1963). The Lower Hunter Valley region has a mean annual precipitation of 70 cms. which is normally evenly distributed throughout the year, but which is erratic enough to cause frequent floods and droughts (Tweedie, 1963). In the Wyong area rainfall is higher (105 cms./year) with an ill-defined summer maximum with less variation from year to year than the Lower Hunter Valley. Annual mean temperatures are similar (about 18° C.) but extremes are greater in the more inland Lower Hunter Valley area.

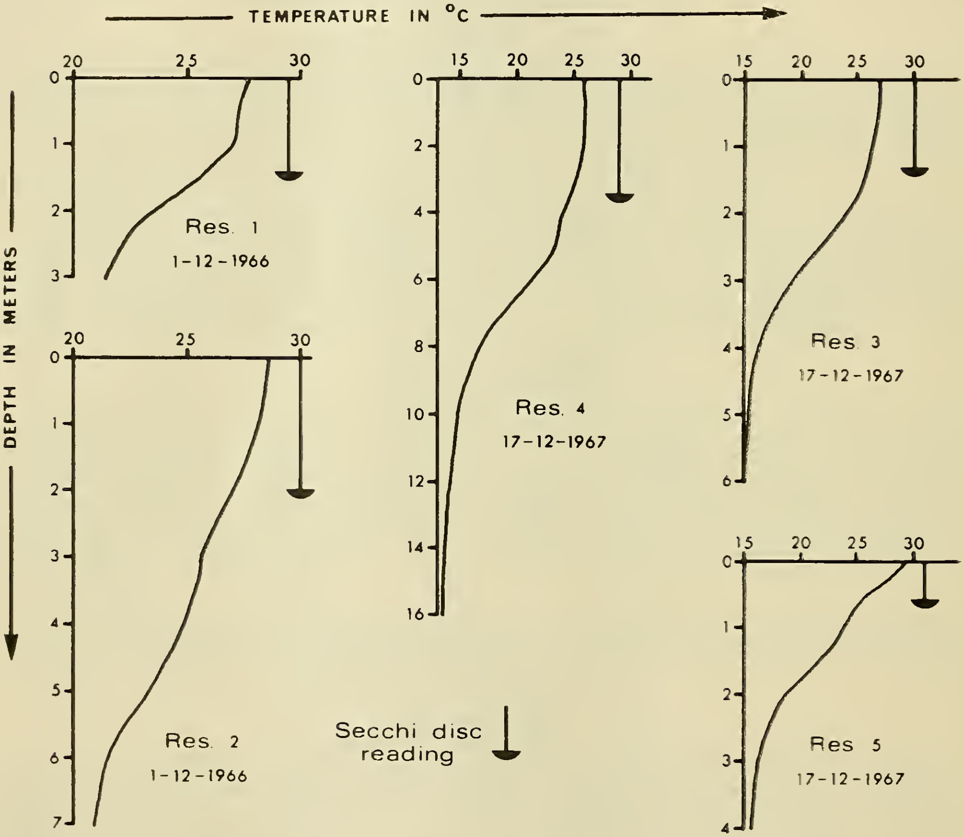

Fig. 1. Summer temperature profiles for the five reservoirs.

METHODS

The reservoirs were sampled over various periods (Table 1). In each case the sampling interval was fortnightly for the first year, then monthly. Two stations were established in each and their positions maintained by aligning landmarks. One was in the deepest part and was used for physico-chemical measurements, while the other, the zooplankton collection course, was approximately 150 metres long. Each reservoir was sampled at a fixed time of day (Table 1) so that the results for each trip are comparable. Any variation between the reservoirs due to different diurnal sampling times has been neglected in the analyses.

The physicochemical parameters measured (with methods in parentheses) were depth (fixed graduated stick), temperature (resistance thermometer accurate to ± 0·1° C.), dissolved oxygen (Winkler method (Welch, 1948)), transparency (Secchi disc), pH (determined in the laboratory on the same day with a "Pye Dynacap" meter) and total dissolved solids (evaporation to dryness at 110° C.). Rainfall and temperature data for Cessnock and Wyong were provided by the Commonwealth Bureau of Meteorology.

A conical net (30·5 cm. diameter, 102 cm. long, mesh size 30/cm.) was used to collect zooplankton. It was towed at about 50 cm/sec so that the 150 m. course was covered in 5 mins. The nets were towed obliquely for a minute at each of five depths. In reservoirs 2 and 4 the depths used were 5 m., 4 m., 3 m., 2 m. and 1 m., while in the remainder 2·5 m., 2 m., 1·5 m., 1 m. and 0·5 m. were used. This method gave a representative sample of reservoir zooplankton, but is no more than semi-quantitative. Three identical nets were used so that there was always a washed and dried net available for sampling. In this way it is hoped that no accidental introduction of zooplankters was made.

Samples were preserved in 5% formalin. Entomostraca were enumerated according to the methods of Timms (1967) and the abundance of other planktonic organisms was noted, using a four-point scale.

PHYSICOCHEMICAL ASPECTS

1. *Results*

These are expressed in summary form in Tables 2–4 and Figure 1. Those for Abernethy Dam are given in more detail (Fig. 2) because, while they tend to be representative of conditions in the five reservoirs, they show relationships between physical and chemical factors in an extreme environment.

TABLE 2
Summary of temperature data

Reservoir		Minimum			Maximum			Average range
		1966	1967	1968	1966–67	1967–68	1968–69	
1	Surface	10·2	11·6	11·6	27·8	31·6	26·2	17·4
	Bottom	10·2	11·4	11·0	22·0	22·4	23·2	11·7
2	Surface	12·0	13·5	12·7	28·5	30·7	27·0	16·0
	Bottom	11·8	13·4	12·7	21·8	21·4	22·1	9·1
3	Surface	11·1	11·9	11·2	31·2	33·7	—	21·4
	Bottom	10·6	11·0	11·1	18·0	14·0	—	5·9
4	Surface	—	12·7	12·4	—	26·5	26·4	13·8
	Bottom	—	12·7	11·7	—	13·6	12·8	1·0
5	Surface	—	10·0	11·3	—	29·2	—	19·2
	Bottom	—	9·3	10·9	—	15·6	—	6·3

2. *Discussion*

Annual surface temperature range may be 20 centigrade degrees (Table 2). There are a number of factors determining the extent of this range. As expected, temperature range diminished with increasing depth (see Tables 1 and 2). In the present series any contribution that wind protection would make to increased range would only reinforce the influence of depth, since the shallower reservoirs are also the protected ones.

Turbid waters are warmer than clear ones under the same circumstances (Hussainy, 1967) and since transparencies were lower in the 1967–68 summer than in others (e.g., Abernethy Dam, Fig. 2) the highest water temperatures were recorded then despite no appreciable difference in air temperatures. The use of reservoir 2 as a cooling pond resulted in significantly higher winter temperatures, but those in summer were little affected.

The summer temperature profiles (Fig. 1) indicate stratification, but its duration and nature are variable in each reservoir. Reservoir 4 is a typical warm monomictic lake and lack of deoxygenation of the hypolimnion (Table 3) indicates oligotrophy. Reservoirs 3 and 5 are also warm monomictic lakes.

TABLE 3

The nature and extent of stratification

Corresponding data for reservoir 3 is incorporated in Fig. 2

Reservoir	Date	Temperature (m. °C.)		Oxygen (Percentage saturation)	
		Surface	Bottom	Surface	Bottom
1	1.12.66	27·6	21·4	121	44
	16.12.66	24·4	22·5	105	85
	30.12.66	25·6	23·8	102	97
	15. 1.67	27·8	22·0	115	56
	1. 2.67	21·2	19·8	101	100
2	16.11.66	25·1	20·0	119	100
	1.12.66	28·5	20·6	120	68
	16.12.66	24·1	21·1	101	100
	30.12.66	26·1	21·4	99	58
	15. 1.67	28·5	21·8	108	64
	1. 2.67	24·9	22·0	118	111
4	22.10.67	18·1	13·0	109	100
	17.12.67	26·0	13·6	105	94
	4. 2.68	26·0	13·8	107	100
	3. 3.68	26·5	14·0	122	98
	28. 4.68	21·6	14·0	111	104
5	22.10.67	16·2	14·9	80	67
	17.12.67	29·2	15·6	104	13
	4. 2.68	25·6	16·6	90	3
	3. 3.68	24·7	16·5	91	7
	28. 4.68	17·0	16·3	88	51

Despite their shallowness there is a distinct epi–, meta– and hypolimnion and extensive deoxygenation of the latter (Table 3, Fig. 2). From the available data (Table 3), reservoirs 1 and 2 undergo intermittent summer stratification with deoxygenation of the bottom layers (a hypolimnion is poorly developed—Fig. 1). Deoxygenation in the bottom layers of reservoirs 1, 2, 3 and 5 would indicate that they are eutrophic. At least for the first two the large numbers of zooplankters present (see later) confirms this. Reservoir 5 is probably not eutrophic considering the low zooplankton standing crop (see later). In this case decomposition of the highly organic mud soon deoxygenates the small-volumed hypolimnion.

The low transparencies in the smaller reservoirs allow the shallow water to stratify (Eriksen, 1966). In this respect, stratification in Abernethy Dam (Fig. 2) was more striking and enduring in the 1967–68 summer than in the previous summer when transparencies were higher. The intermittent nature of stratification in reservoirs 1 and 2 is associated with their relatively exposed position and the occurrence of "southerly busters". Weatherley

(1958) has recorded short-lived stratification because of wind action in Tasmanian farm dams, while Moss (1969) has attributed persistent stratification in a 4 m. deep English pond to protection from wind. Clearly relative lack of wind and high turbidity may combine to create stable conditions in small lentic waters.

The low transparencies in reservoirs 1, 2 and 3 (Table 4) were due mainly to suspended silt and clay though occasionally phytoplankton blooms contributed significantly. Water colour, together with silt following rain, was responsible for the low values in reservoir 5.

The relatively low bicarbonate concentrations for reservoirs 4 and 5 (see Timms, 1970) probably accounts for their low mean pH values (Table 4), though in reservoir 5 humic acids may have contributed also (Ruttner, 1963).

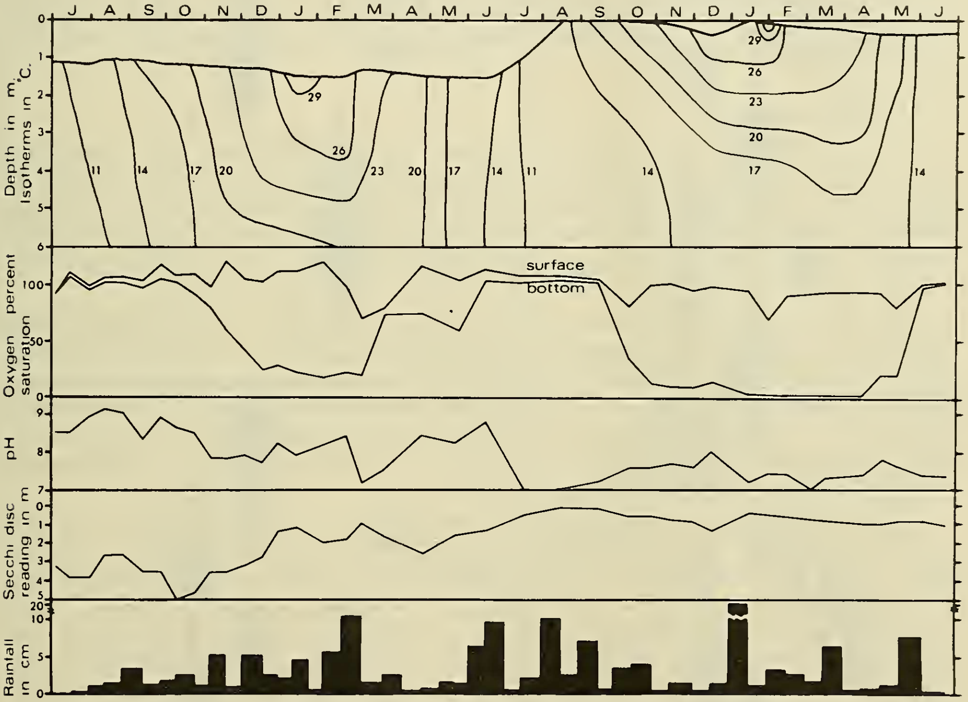

Fig. 2. Seasonal changes in water level, temperature, surface and bottom dissolved oxygen content, pH, Secchi disc reading and rainfall for reservoir 3.

Fluctuations in total dissolved solids were large in some cases (Table 4) and have been shown to be greater in reservoirs with larger rates of water renewal (Timms, in Press).

In the four reservoirs 1, 2, 3 and 5, receiving water by runoff, there is a correspondence between transparency, pH and rainfall. Taking Abernethy Dam as an example (Fig. 2), there were usually marked decreases in transparency and pH after moderate or heavy rains. In Australia (see also Timms and Midgley, 1969; Weatherley, 1958) and in some tropical situations (e.g., Imevbore, 1967; Jayangoudar, 1964) these changes are more extreme and more usual than in the north temperate zone (e.g., Rutner, 1963). In these small reservoirs any seasonal influence on transparency and pH is largely or completely masked by these changes, whereas in larger ones (e.g., Somerset

Dam [Stephenson, 1953], Borumba Dam [Timms and Midgley, 1969] and even Mardi Dam) this is not true. In these, transparency is maximal in winter and pH highest in summer.

PLANKTON CYCLES

1. *Phytoplankton*

Comments on the plant plankton are limited to four species which were large enough to be retained by the zooplankton net. *Microcystis aeruginosa* (Kuetz.) Elenkin occurred occasionally in reservoir 2, while in reservoir 1 it was present throughout the year, blooming in late summer and autumn. *Ceratium hirudinella* (O.F.M.) Duj. was common, except in summer, in reservoir 2, and was occasionally present in reservoirs 1 and 4. Although recorded from reservoirs 1, 3 and 4 *Volvox* sp. bloomed (in late summer) only in reservoir 1. *Oscillatoria* (? *princeps* Vaucher) occurred in late summer in reservoirs 1, 3, 4 and 5. It is significant that blooms were noted only for reservoir 1, which is considered the most productive, and that they occurred in late summer to autumn.

2. *Entomostraca*

(*a*) *Blooms*.—These usually occurred between October and December and in March, i.e., in spring and autumn (Fig. 3). In all reservoirs entomostracan numbers during blooms were 100–1,000 times those in normal periods. A single bloom each year in spring was characteristic of reservoirs 1, 2 and 3, while reservoirs 4 and 5 had regular spring and autumn or early winter blooms.

Few species were responsible for these blooms. *Boeckella fluvialis* was usually important in reservoir 1, and occasionally in reservoir 3. The peaks in reservoirs 4 and 5 were due to fluctuations in *Boeckella minuta* numbers, though *Mesocyclops leuckarti* and *Bosmina meridionalis* occasionally contributed. *Daphnia carinata* was the most important species in reservoir 3, and *D. lumholtzi* in reservoirs 1 and 2. *Ceriodaphnia cornuta* occasionally contributed, but only in reservoirs 1 and 2.

The variability in magnitude and timing of the peaks (Fig. 3) shows little relationship to the physicochemical parameters measured. However, floods, with their associated higher hydrogen ion concentrations, turbidities, and probable increased level of nutrients, were often followed by peaks. Thus in reservoir 3, the sustained bloom of September-January followed the August, 1967 flood and the small blooms in reservoir 1 in April and June, 1968 followed minor floods in March and May. The large flood of January, 1969 did not initiate any peaks; indeed, it probably caused the one in

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Legend of Figure 3 on opposite page—

Fig. 3. Seasonal abundance and species periodicity of Entomostraca in the five reservoirs. Species code:

1. *Boeckella fluvialis* Henry
2. *B. minuta* Sars
3. *Calamoecia lucasi* Brady
4. *Gladioferens spinosus* Henry
5. *Mesocyclops leuckarti* (Claus)
6. *Eucyclops serratulus* (Fischer)
7. *Macrocyclops albidus* (Jurine)
8. *Daphnia carinata* King
9. *D. lumholtzi* Sars
10. *Ceriodaphnia cornuta* Sars
11. *Simocephalus acutirostratus* (King)
12. *S. elizabethae* (King)
13. *Moina micrura* Kurz
14. *Ilyocryptus spinifer* (Herrick)
15. *Diaphanosoma excisum* Sars
16. *Bosmina meridionalis* Sars
17. *Alona kendallensis* Henry
18. *A. davidi* Richard
19. *Alona* sp.
20. *Camptocercus similis* Sars
21. *Chydorus eurynotus* Sars
22. *Chydorus* sp.
23. *Dunhevedia crassa* King
24. *Leydigia acanthocercoides* (Fischer)
25. *Newnhamia fenestrata* King
26. *Cypridopsis australis* Henry

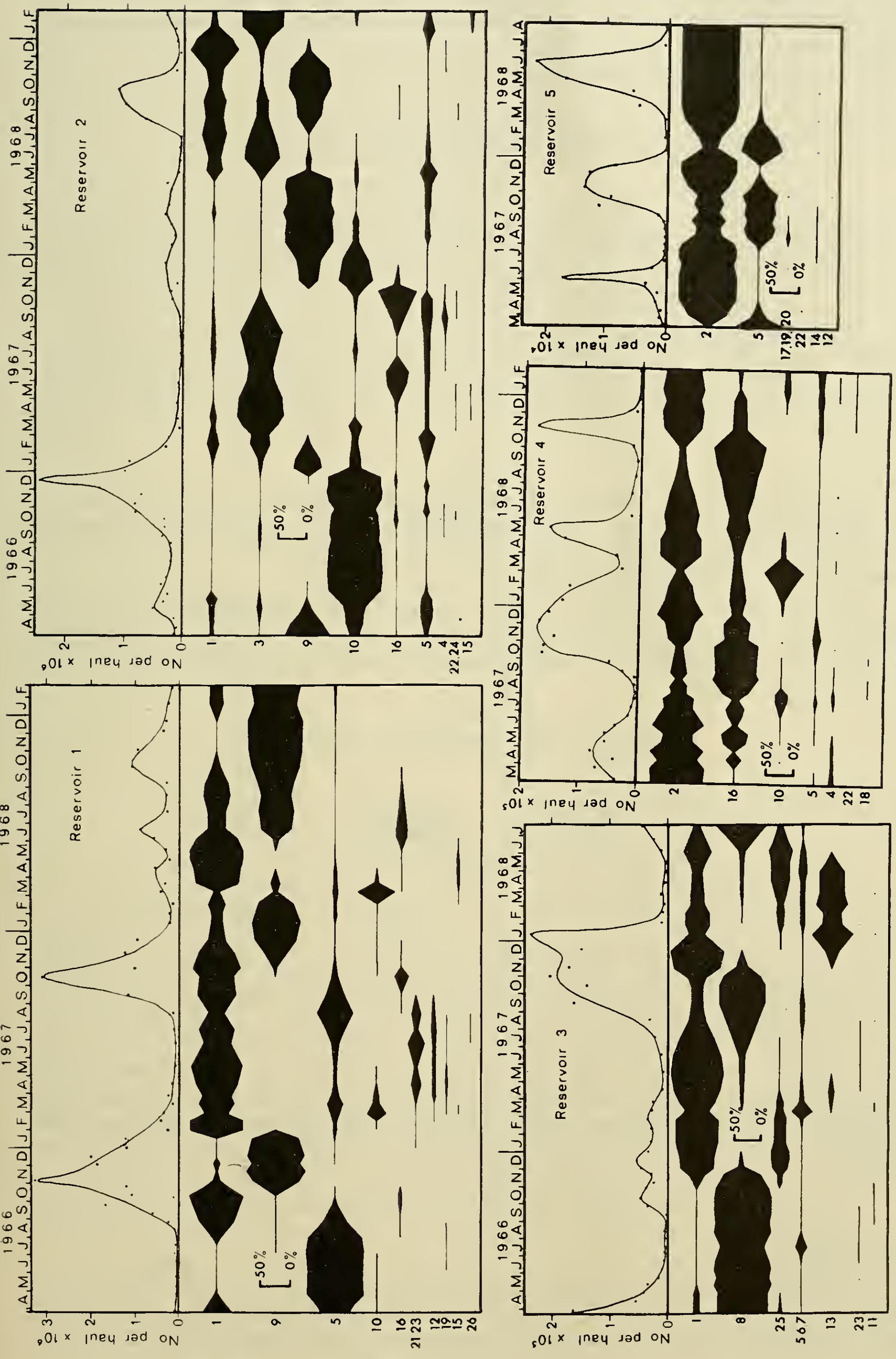
Reservoir 1
Reservoir 2
Reservoir 3
Reservoir 4
Reservoir 5
1966
1967
1968
A,M,J,J,A,S,O,N,D,J,F,M,A,M,J,J,A,S,O,N,D,J,F,M,A,M,J,J,A,S,O,N,D,J,F
No per haul x 10⁶
No per haul x 10⁵
50%
0%
1
9
5
10
16
21 23
12 19 15
26
3
4
22 24
15
8
25
5 6 7
13
23 11
2
18
17,19,20
14
12

Fig. 3.

reservoir 3 to subside. Floods have little effect on water levels in reservoirs 2, 4 and 5 because of their construction. Peaks are regular in 4 and 5 and are less regular in 2. Clearly floods upset peak regularity, but other unknown factors must also operate. Perhaps one of these is biological since *Boeckella minuta* is present and *Daphnia* sp. absent from the two stable reservoirs.

TABLE 4

Summary of data on Secchi disc readings, pH and T.D.S.

Reservoir	Secchi disc (in cms)			pH			T.D.S. (in p.p.m.)		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
1	27	328	132	6·9	9·0	7·7	127	338	205
2	62	458	175	6·9	9·0	8·1	858	1,152	996
3	22	500	190	7·0	9·1	7·8	153	282	205
4	220	520	352	6·7	7·8	7·0	123	169	152
5	13	127	71	5·7	6·7	6·1	68	197	139

In each reservoir there is a characteristic maximum for numbers of organisms during a bloom. For reservoirs 1 and 2 it lies between 2·5 and 3 million/haul, for reservoirs 3 and 4 the figure is 0·2 million/haul, and for reservoir 5 it is 0·02 million/haul.

(*b*) *Species Composition.*—Table 5 reveals that the number of species present at any one time is twice the number of species that cause blooms, but half the total number recorded from the plankton over the study period.

TABLE 5

Comparative species composition of Entomostraca

Reservoir	Number of species causing blooms	Average momentary species number	Total number of species recorded for limnetic region
1	3	5·3	11
2	2	5·3	10
3	2	4·3	9
4	2	5·1	7
5	2	3·6	8
Average ..	2·2	4·7	9·0

The average momentary species composition for the five reservoirs is 2·4 copepodan and 2·3 cladoceran species. These figures vary seasonally (Table 6). The changes are much greater for the Cladocera, but for both the minimum is in summer and the maxima are in March-April and August-October.

(*c*) *Seasonal Distribution of Species.*—Sufficient data is available for most species (Fig. 3) for conclusions to be drawn on their seasonal distribution.

Daphnia lumholtzi was usually most abundant between November and February and often absent during winter. Ephippial eggs were rarely formed and were found only in reservoir 1 towards the end of the 1966–67 summer. It is probably significant that following this period *D. lumholtzi* was absent for many months while the water level was low. Unlike *D. lumholtzi*, *D. carinata* was a winter-early spring form, absent during summer. Ephippial eggs were formed each year, but were most abundant during the 1966–67 drought.

Ceriodaphnia cornuta was most abundant during December to March, but it was occasionally common at other times. The seasonal occurrence of *Bosmina meridionalis* was quite variable, but it tended to bloom in early spring. Both *Moina micrura* and *Diaphanosoma excisum* occurred for a short period in late summer to early autumn.

The remaining cladocerans were littoral strays; hence their presence in the limnetic region was erratic, though some periodicity was apparent. Thus *Simocephalus* spp. were often found during August-October, *Alona* spp. during June-August, and other chydorids March-September.

Two ostracods were encountered. *Newnhamia fenestrata* was a regular component of the limnetic plankton in reservoir 3, occurring during summer and autumn. *Cypridopsis australis* was present in reservoir 1 during the low water levels of mid–1967.

TABLE 6

Seasonal variation in average number of Entomostracan species for all reservoirs

Month	Copepoda	Cladocera
January	2·2	1·8
February	2·4	1·4
March	2·6	2·6
April	2·2	3·0
May	2·4	2·2
June	2·4	2·6
July	2·4	2·4
August	2·8	3·4
September	2·6	2·8
October	2·4	2·8
November	2·4	1·2
December	2·2	1·2

The calanoids, *Boeckella fluvialis, B. minuta* and *Calamoecia lucasi*, were present throughout the year. The abundance of *B. fluvialis* and *C. lucasi* varied erratically while *B. minuta* bloomed regularly in spring and autumn. *B. fluvialis* was apparently favoured by the low water levels during the first half of 1967 in reservoirs 1 and 3. *Gladioferens spinosus* had a distinct spring periodicity in reservoir 2, but in reservoir 4 it occurred between late summer and winter.

Mesocyclops leuckarti is the only species found in all five reservoirs. It was usually most abundant between November and March, but peaks at other times were not uncommon. In that most of the peaks followed floods, conditions must have been most favourable then.

3. *Other Zooplankters*

Five genera of rotifers were noted. *Keratella*, *Brachionus* and *Asplanchna* occurred in all five reservoirs with *Filinia* and *?Monostyla* in reservoir 1 also. *Keratella* and *Brachionus* were never abundant and occurred during summer to autumn. Perhaps more than one species of *Asplanchna* was present, for cycles and time of blooming were variable.

Anisops sp. (Notonectidae) and *Chaoborus* sp. were always present in the net plankton in reservoir 3. The latter also occurred in reservoir 5. Each reservoir contained a species of hydracarinid which was most common in late summer. Reservoir 1 irregularly contained a second species.

In summer prawn larvae (*Paratya* sp.) were regular components of the plankton of all five reservoirs, especially 1 and 3. In the latter the few adults collected proved to be *P. australiensis* Kemp.

Discussion

Small lakes lack consistent plankton cycles (Pennak, 1949). In Australia this is true of both small dams (Weatherley, 1958) and even larger ones (e.g., Borumba Dam—*op. cit.*), the major factor causing irregularity being the variable incidence of floods. In the present study the three reservoirs (1, 2 and 3) providing the most variable physicochemical environment, i.e., most prone to flooding, are the ones with the most inconsistent cycles. Floods might either initiate or destroy blooms, depending on their severity and on other factors such as the nutritional value of flood water, whether stratification is upset and turbidity changes (Imevore, 1967).

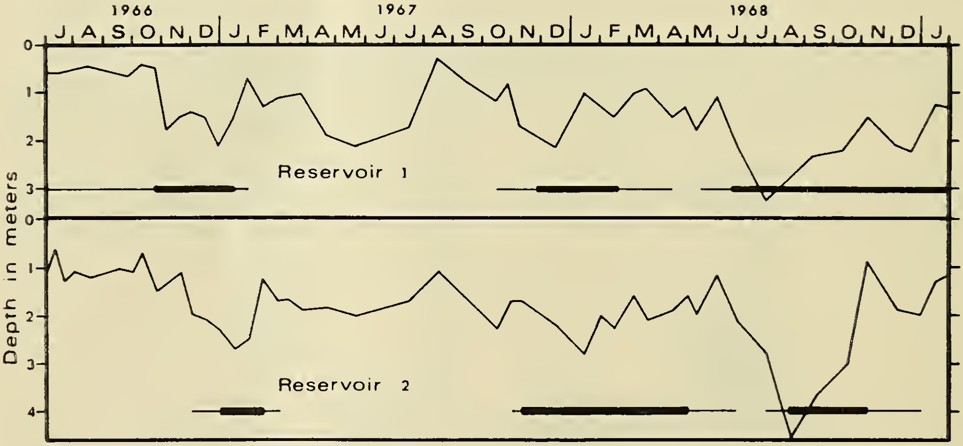

Fig. 4. Relationship between Secchi disc readings and the occurrence of *Daphnia lumholtzi* in reservoirs 1 and 2. Thin line indicates that *D. lumholtzi* was present, and thick line that it was abundant.

The low water levels during the first half of 1967 in reservoirs 1 and 3 allowed *Najas tenuifolia* R. Br. and *Ceratophyllum demersum* L. in the former and *Potamogeton tricarinata* A. Benn. in the latter to grow in the limnetic regions. In reservoir 1 the growth was relatively greater and concomitantly there was a persistent bloom of *Microcystis*. It is significant that during this period littoral strays were most common, particularly in reservoir 1. The blue green algae bloom probably contributed to the abundance of *Chydorus* sp. (Hutchinson, 1967, p. 624).

There is little correlation between seasonal occurrence of species and the physicochemical factors measured, save temperature. The severe deoxygenation in reservoirs 3 and 5 seemed to have little effect on species numbers, though floods did (see earlier).

Jolly (1966) has shown that turbidity as well as temperature is important in determining the seasonal periodicity of *Daphnia carinata* and *D. lumholtzi*, the former being a turbid water species and the latter a clear water one. Data from reservoirs 1 and 2 (Fig. 4) certainly support this conclusion for

D. lumholtzi. That high transparency is not the only necessary factor for population development is seen for late summer and autumn of 1967 when, although the water was clear, no population developed. Temperatures were obviously not suitable then.

For *D. carinata* in reservoir 3 (Figs. 2 and 3) there is no relationship between turbidity and seasonal occurrence, for a bloom occurred during a clear water period (in October, 1966) and one subsided when turbidity was high (in November, 1967). Perhaps this contradictory situation is explained by a supposed absence of planktivorous fish in this reservoir as opposed to their presence in the reservoir studied by Jolly. Since *D. carinata* is a large cladoceran it could only bloom during turbid periods when it could escape the attention of planktivorous fish.

There have been few studies on the seasonal occurrence of Entomostraca in Australia, so there is little data for the comparison of present results. However, what there is spans wide latitudes (at low altitudes) in eastern Australia [Borumba Dam (*op. cit.*)—26° 30″ S; University Pond, Brisbane (Timms, 1967)—27° 30″ S; Sydney Water Supply Reservoirs (Jolly, 1966)—34° 00″ to 34° 30″ S; Jock Marshall Reserve Pond (Geddes, 1968)—38° 00″ S; and Lakes Purrumbete and Elingamite (Hussainy, 1969)—38° 20″ S]. The present reservoirs are at 33° 00″ S.

Three species occur at all latitudes. *Daphnia lumholtzi* is absent during summer in the north, but only present then in the south. In the central coast reservoirs it occurs for longer periods during the warmer months than further south. The seasonal occurrence of *Bosmina meridionalis* is variable in the centre and north, but has a distinct summer periodicity in the south. *Mesocyclops leuckarti* is found all year round in all areas.

The central and the north region share two species. *Diaphanosoma excisum* is a summer form in both. *Boeckella minuta* is perennial, but in the north it is only abundant during winter-spring, while in the central region there are regular spring and autumn blooms.

Two species occur in both the central and southern areas. *Moina micrura* has a distinct late summer-autumn periodicity in both. A striking summer periodicity for planktonic *Moina* species is characteristic (Hutchinson, 1967, p. 619). *Daphnia carinata* is a winter-early spring form in the central region, but occurs from late spring to early autumn in the south.

There are basic differences between the Cladocera and Copepoda in the relationship of life cycle to seasonal changes in habitat. The eulimnetic Cladocera are probable aestival species, though for most there is no evidence for the production of resting eggs. *Bosmina meridionalis* would appear to be aestival in some reservoirs, but is certainly perennial in reservoir 4. Some, e.g., *Moina micrura*, are certainly monacmic, but most are probably di- or polyacmic. The Copepoda, on the other hand, are perennial and di- or polyacmic. Although no life history studies were made, casual observations suggest that most species, particularly the copepods, are multivoltine, though some, e.g., *Moina micrura*, *Diaphanosoma excisum*, are possibly univoltine.

Comparing the momentary species composition for the five reservoirs with that for north-eastern New South Wales as a whole (Timms, 1970), the figures for copepods are similar (2·4 and 2·3 respectively) but that for cladocerans is much higher (2·3 as against 1·1). This latter difference is due to littoral strays in the smaller reservoirs. The seasonal change in the momentary species composition agreed with that for north-eastern New South Wales (*op. cit.*) but were more pronounced. The summer minimum in diversity is also recorded for overseas freshwater zooplankton communities (Pennak, 1957).

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